

Research Article

Pilot Testing of CAN Digital Apps to Improve the Quality of Life of Cancer and Benign Brain Tumor Survivors

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Abstract

Objective: Vestibular Schwannoma (VS) and breast cancer patients experience negative Quality of Life (QoL) impacts. VS patients struggle with mood disorders, whereas breast cancer patients experience treatment-related cognitive impairment. Improving QoL in these patient populations is the objective of these digital app technologies involving music, art and robotic pet therapies.

Methods: Active Receptive Music for Cancer (ARMCAN) recruited ten breast cancer patients who were randomized into an interactive music therapy group and a receptive music therapy group, occurring daily for 15 minutes over 6 months. The primary endpoint was Functional Assessment of Cancer Therapy - Cognitive Function (FACT-Cog) scores. Sensory Integrative Therapy with Art and Robots (SITAR) recruited ten VS patients to undergo art therapy alone or art therapy and robotic companion therapy weekly for twelve weeks. One patient in each group completed the study. The primary endpoint was Mental Health Quality of Life Questionnaire (MHQOL) surveys with a secondary endpoint of Hamilton Depression scale (HAM-D).

Results: For ARMCAN, integrative music therapy led to an increase in FACT-Cog scores of 44.2% and 12.4% for the interactive (n = 3) and receptive music (n = 3) groups, respectively. For SITAR, there were 106% and 63.6% increases in MHQOL scores for the art intervention (n = 1) and combined therapy groups (n = 1), respectively. There was an average decrease of 80% in HAM-D scores.

Conclusion: This pilot study primarily demonstrates feasibility for digital applications to improve QoL in breast cancer and VS patients. There is preliminary data to support that integrative music therapy can improve treatment-induced cognitive impairment in breast cancer patients. Similarly, art and robotic animal companion therapy may improve overall QoL and reduce depressive symptoms in vestibular schwannoma patients.

Keywords: Quality of Life; Treatment-Related Cognitive Impairment; Vestibular Schwannoma; Breast Cancer; Art Therapy; Robotic Animal Companion Therapy; Music Therapy; Integrative Medicine

Abbreviations

ARMCAN: Active Receptive Music patient application (app); ARTCAN: Art Therapy patient application (app); ARCCAN: Animal Robotic Companions application (app); FACT-Cog: Functional Assessment of Cancer Therapy - Cognitive Function; HAM-D scale: Hamilton Depression rating scale; MHQOL: Mental Health Quality of Life questionnaire; SITAR: Sensory Integrative Therapy with Art and Robots

Introduction

Both cancer diagnosis and treatment have negative impacts on patient Quality of Life (QoL) [1-3]. Modern cancer treatment has a host of side effects including, but not limited to, peripheral neuropathy, nausea, pancytopenia, pain, cognitive impairment and others. While physicians naturally focus on treatment and symptom management, the issue of QoL is often overlooked and therefore rarely studied. Data suggests that mental health issues such as depression and anxiety, which can be a byproduct of worsened QoL, can lead to worse outcomes in several cancer subtypes [4,5]. In the two feasibility studies below, we offer several integrative approaches to improving QoL in two different cancer populations.

The first patient population studied was breast cancer patients. Breast cancer is the most frequently diagnosed cancer in the world, with approximately 2.3 million newly diagnosed cases per year the GLOBOCAN 2020 study [6]. Breast cancer survivors have more issues with cognition and mental health compared to women without history of cancer, suggesting a need for QoL improvement stratagems [7,8]. The second patient population was patients with VS (acoustic neuromas) which are Schwann cell-derived tumors typically affecting the facial (CNVII) or vestibulocochlear (CNVIII) nerves in the cerebellopontine angle (CPA) or exclusively within the internal auditory canal [9-11]. Most VS cases are sporadic while about 5% of cases are a product of the genetic syndrome neurofibromatosis type II (NF2) [11,12]. It is the third most common intracranial nonmalignant tumor with an overall incidence of 1.09 per 100,000/year in the US [10,13,14]. Given the location of VS, the symptoms of headache and balance issues have been shown to have the greatest negative impact on patient QoL [15,16]. Given such, our studies focused on addressing treatment-related cognitive deficits in breast cancer patients and improving general QoL in VS patients.

Regarding treatment-related cognitive deficits, secondary brain tumors and neurocognitive damage from radiation or chemotherapy are often the most common neurologic sequelae in cancer patients and breast cancer patients, specifically [17-19]. Colloquially termed “chemobrain” or “brain fog”, Treatment-Related Cognitive Impairment (TRCI) has a negative effect on patient QoL [20,21]. As breast cancer has a favorable survival rate, the incidence of TRCI tends to be higher in this patient population compared to other cancers [22]. Reported TRCI incidence rates in breast cancer vary greatly with an average of ~50% [23-25]. The first of the studies aimed to show a proof of concept for reducing TRCI in breast cancer patients using active versus receptive music therapy. Music-based therapy has preliminarily been shown to improve cognitive function in both Alzheimer’s disease and stroke patients [26-28]. Music therapy has been studied in the breast cancer patient population in relation to improving mood rather than cognitive deficits [29].

The second study discussed aimed to improve general QoL in VS patients via a combination of art and robotic animal companion therapy. QoL issues are a common problem in VS patients, so much so that there is a disease-specific scale called the Penn Acoustic Neuroma Quality-of-Life Scale (PANQOL) [30]. A new diagnosis of VS imparts a decrease in QoL as measured by the PANQOL [31]. Our study attempted to address this treatment gap with the use of art therapy and robotic animal companions. Art therapy has already been studied in non-psychotic mental health disorders, showing a significant positive change in mental health symptoms compared to control with limited adverse effects [32]. Art therapy has been shown to reduce symptoms of depression and anxiety in cancer patients but has not been specifically studied in the VS population [33,34]. Moreover, animal-assisted interventions have already been employed in hospitals for a broad spectrum of conditions, including cancer [35]. However, the success of animal therapy is capped by the limited supply of therapy pets. Thus, there has been a development in robotic animal companions which can be widely accessible and, depending on the quality of the robotic pet, effective. In fact, robotic pets have been shown to enhance well-being and QoL in older adult patients with dementia [36].

Given this preliminary data, the first study aimed to show the feasibility of using music therapy to improve TRCI in breast cancer patients termed Active Receptive Music for Cancer (ARMCAN). The second study aimed to show the feasibility of improving QoL in VS patients with art therapy alone using a web-based application termed Art Therapy for Cancer (ARTCAN) and a

combination of art and robotic animal companion therapy. The combination of ARTCan and robotic animal companion therapy is termed Sensory Integrative Therapy with Art and Robots (SITAR). With the small n of a feasibility study, we present the preliminary survey data from validated QoL metrics but cannot draw conclusive evidence for efficacy.

Methods

1. Patient Accrual and Study Design

- a. *ARMCan*: Patients were recruited from the University of Cincinnati Medical Center between 2020 and 2022. 10 patients were accrued for this study. Inclusion criteria were patients who: (1) had a breast cancer diagnosis, (2) previously completed chemotherapy, (3) were 21 years old or older, (4) identified having cognitive dysfunction and (5) confirmed having reliable internet access to use ARMCan. Exclusion criteria were patients who were: (1) younger than 21, (2) receiving active chemotherapy (immunotherapy, neoadjuvant chemotherapy, targeted therapies such as Herceptin and Perjeta, or post-chemotherapy hormone therapies were not considered exclusionary), (3) previously diagnosed with unstable mental illness, (4) with active malignant cancers, (5) known to have allergy to MRI contrast, (6) diagnosed with comorbid neurodegenerative disease or those taking drugs with known cognitive effects (i.e. benzodiazepines), (7) diagnosed with complete bilateral hearing loss, or (8) unable to consent. After ten eligible patients were accrued, a third party randomized the subjects into Group A (n = 5) or Group B (n = 5) (Fig. 1). ARMCan is a web-based digital art therapy application designed and created by Dr. Rebola and graduate students under her supervision at the University of Cincinnati. The ARMCan app was designed with two modalities for the study - active and passive music therapy. Participants in Group A used the ARMCan app to create music (active) to express their mood by composing their own music from a choice of instrumental genre (i.e., classical). Group B participants engaged in receptive (passive) listening to instrumentals from a choice of a genre. Each session consisted of daily music therapy for a total of 15 minutes a day for 6 months.
- b. *SITAR*: Patients were recruited from the University of Cincinnati Medical Center between 2020 and 2022. 10 patients were accrued for this study. Inclusion criteria were patients who: (1) had a VS or NF2 diagnosis, (2) experienced unilateral or bilateral hearing loss secondary to the tumor, (3) self-reported mood issues, (4) were 18 years old or older and (5) confirmed having reliable internet access to use ARTCan. Exclusion criteria were patients: (1) younger than 18 years old, (2) undergoing active treatment for VS or other malignant tumors, (3) diagnosed with a mental illness with recent medication changes especially sedatives, (4) unable to provide consent, (5) who had a physical pet that would limit their interaction with the robotic companion, (6) not interested in art or dogs, or (7) with poor technology literacy. After patient accrual, subjects were randomized into Group A (n = 5) and Group B (n = 5) (Fig. 1). Group A completed art therapy activities and Group B completed art therapy activities AND received a robotic animal companion. Art therapy is also referred to as ARTCan; companion therapy is also referred to as Animal Robotic Companions application (ARCCan). The length of intervention was twelve weeks for both groups. ARTCan is a web-based digital art therapy app designed and created by Dr. Rebola and graduate students under her supervision at the University of Cincinnati. Art therapy occurred once a week with self-directed activities and visits scheduled with a dual board-certified art therapist and licensed psychologist at entry and exit to ensure correct usage of art intervention and reflection on the use of the app. Participants submitted their art activities weekly and QoL assessments via the app. Group B subjects received the aforementioned art therapy as well as a robotic animal-like companion resembling a golden retriever to interact with at their discretion. Their interactions with these robots were tracked via a smart bandana, which tracked the number and length of interactions.

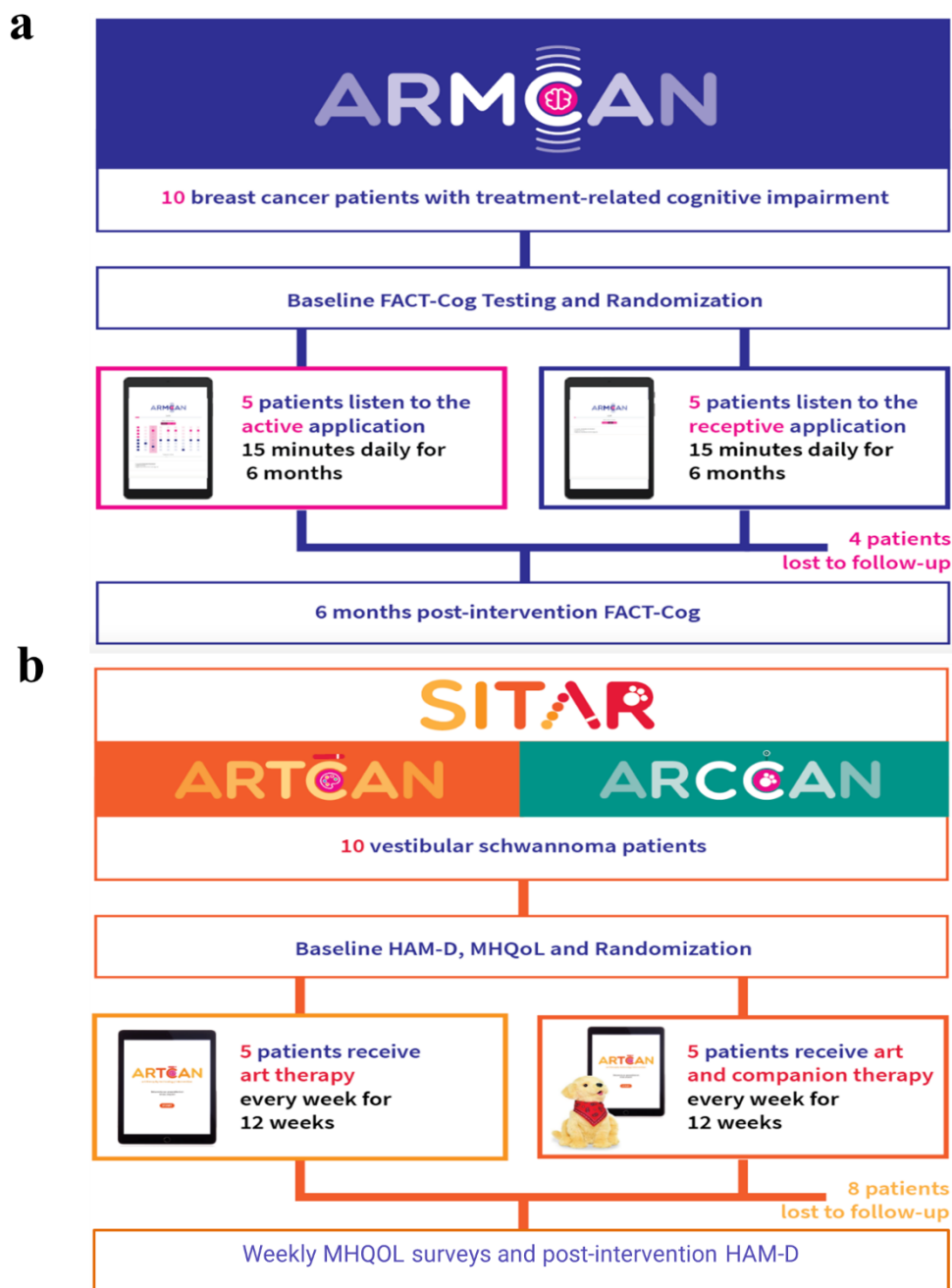


Figure 1: Study designs for ARMCan and SITAR. (a) Study design for music therapy (ARMCan) to improve cognitive impairment in breast cancer patients. (b) Study design for art (ARTCan) and companion (ARCCan) therapies to improve quality of life in vestibular schwannoma patients. The combination of ARTCan and ARCCan is referred to as SITAR.

2. Digital App Creation

- ARMCan:** The ARMCan application (Supplemental Fig. 2) is a web-based platform designed for tablets. The application used a visual Likert scale for mood tracking and directs patients to an active or receptive listening environment. The application allows patients to select the base genre of music to be played, regardless of therapeutic mode. In active therapy, patients co-produce new tracks by adding sounds over the base tracks. In receptive therapy, patients listen to music only. In both cases, music genres include Classical, Latin and Jazz. A database of instrumental music was built for each genre, in which songs are randomly played in each session. Also, in both cases, a fifteen-minute bar timer is displayed to track listening time.
- ARTCan:** The ARTCan application is also a web-based platform designed for tablets. The ARTCan app consists of 12 activities during which participants are guided to produce a drawing (Supplemental Fig. 2a). The activities, one per week, include

prompting patients to draw a: (1) tree, (2) safe or happy place, (3) support system, (4) self-care toolkit, (5) yourself as a plant or flower, (6) biggest fear, (7) deafness, (8) animal, (9) positive feeling, (10) let go, (11) comfort container and (12) bridge. Patients uploaded a photo of the art they created to the application to show proof of completion of art therapy. They also answered questions specific to the art therapy theme for the week. Example of art therapy activity 1: Patients are prompted to "Create an image of your safe or happy place. This is a place where you feel safe, comforted, content and most at home". After art completion, they are asked to upload an image, provide a title and description of their safe/happy place and describe a time when visualizing their safe space might provide comfort (Supplementary Fig. 2).

- c. *ARCCan*: The ARCCan is a product designed for the study as a robotic pet companion with a smart bandana with motion sensors to track patients' interactions with the robotic companion. The bandana camouflages off-the-shelf sensors, which are laced and worn with robotic animal companions by Ageless Innovation (Supplemental Fig. 2). Robotic animal companions come in cats and dogs of different colors. A robot resembling a golden retriever was used for this study.

3. Data Collection

ARMCAN app data usage was monitored and weekly phone calls were made by the study team to ensure compliance. The primary end point was the Functional Assessment of Cancer Therapy - Cognitive Function (FACT-Cog) test to assess cognitive improvement (Supplemental Info). The FACT-Cog tests cognitive dysfunction and QoL in cancer patients who have previously undergone chemotherapy. The FACT-Cog was given at baseline and then 6-months following music therapy intervention. FACT-Cog scoring involved reversal of the following categories to achieve a scoring scale in which higher values correlate to increased cognition: perceived cognitive impairments, impact of perceived cognitive impairments on QoL and comments from others. Furthermore, questions CogMT1, MT2, PMT1 and PMT2 are not currently validated in the FACT-Cog 3rd version and are thus not part of the official score. The max FACT-Cog score is 132 in our scoring schema with higher scores representing improved cognition.

For SITAR, primary endpoints were Mental Health Quality of Life (MHQOL) surveys which were conducted virtually weekly throughout the study (Supplemental Info). MHQOL data had to be converted to a numerical format with higher numbers representing favorable responses (i.e. "I am very satisfied with my relationships" equates to a 4 whereas "I am very dissatisfied with my relationships" equates to a 1). Additionally, Hamilton Depression scale (HAM-D) scores were gathered at enrollment and at 12 weeks following intervention (Supplemental Info). The max HAM-D score is 32 with higher scores representing more depressive symptoms.

Participant Demographics

For the ARMCAN study, we report the demographic data for the six patients included in analysis (Table 1). Given the gender-skew of breast cancer, there was only one male patient in Group B. The average age for patients in Group A was 53.3 years old whereas the average age in Group B was 57 years old. Finally, the race or ethnic background of most patients was white or Caucasian with one black or African American patient in Group B. Data was not kept on the subtype of original breast cancer diagnosis.

Characteristics	Group A (n = 3)	Group B (n = 3)
Gender		
Male	0	1
Female	3	2
Age		
25-44	1	0
45-64	2	2
65+	0	1
Race		
White or Caucasian	3	2
Black or African American	0	1

Table 1: ARMCAN patient demographics.

For the SITAR arm of the study, demographic data was only included for the two patients who completed the full 12 weeks of MHQOL. For the two participating patients, both patients were between the ages of 40-50 with a race/ethnicity of white or Caucasian.

Interactive Music Therapy Improves Cognition in Breast Cancer Patients

FACT-Cog scores for the three patients in the interactive music group (Group A; $n = 3$) and receptive music group (Group B; $n = 3$) were compared pre-therapy and after 6 months which coincided with therapy conclusion (Fig. 2). The pre-intervention FACT-Cog average for Group A was 65 while the pre-intervention average for Group B was 86. Post-intervention FACT-Cog average for Group A was 93.7 and the post-intervention average for Group B was 96.7. This represents 44.2% and 12.4% increases in FACT-Cog scores for Group A and Group B, respectively. P-values were not calculated given the small n for both groups.

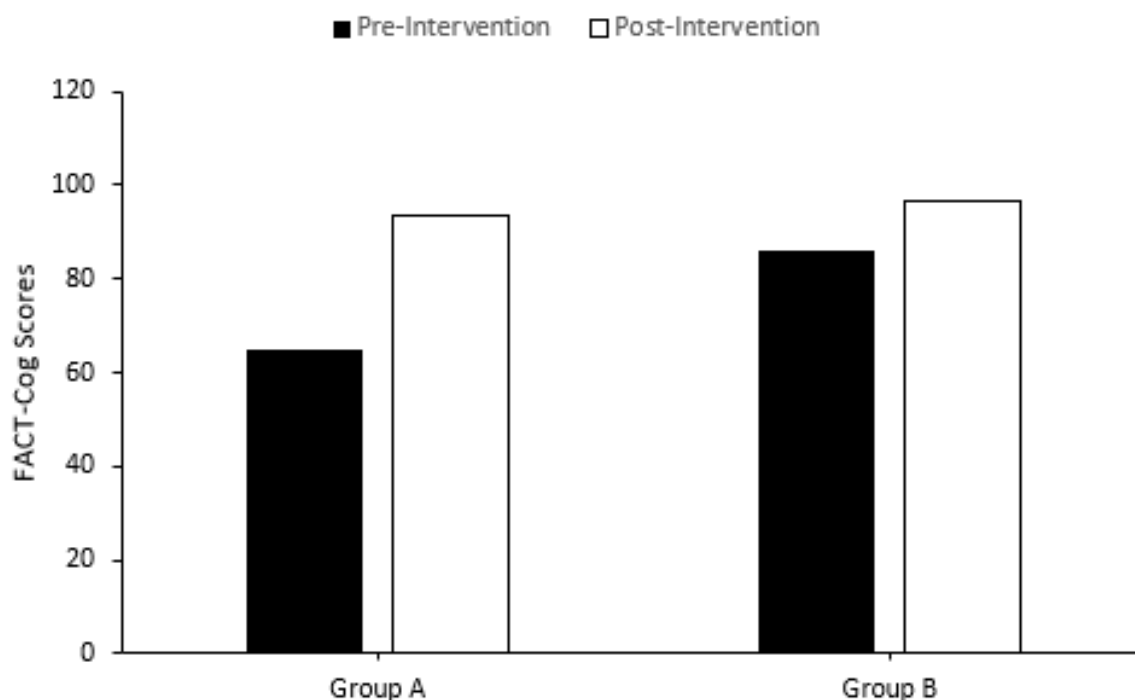


Figure 2: FACT-Cog scores separated by intervention group. FACT-Cog scores were collected at baseline and post-intervention at 6 months. Group A ($n = 3$) is the interactive music group whereas Group B ($n = 3$) is the receptive music group. Both groups improved FACT-Cog scores after intervention with the interactive music group having a larger percentage increase.

Art and Robotic Companion Therapies Increase and Sustain QoL in VS Patients

MHQOL were collected weekly for both the art (Group A) and art and companion therapy (Group B) groups. Only 2 patients completed the full 12-week program and thus were included in the following analysis. 1 patient was in Group A while 1 patient was in Group B. The max score for the MHQOL survey is 46 with higher scores representing improved QoL as perceived by the patient. The initial average for all subjects was 20 with the final MHQOL average at the end of the intervention being 36.5 (Fig. 3). To determine whether Group A or Group B had a larger effect on QoL, data was separated by treatment group (Fig. 3). Both groups achieved increases in MHQOL scores after week 1 and sustained this benefit throughout the trial. There was a 106% increase in MHQOL scores for the art intervention group and a 63.6% increase for the art and companion therapy group.

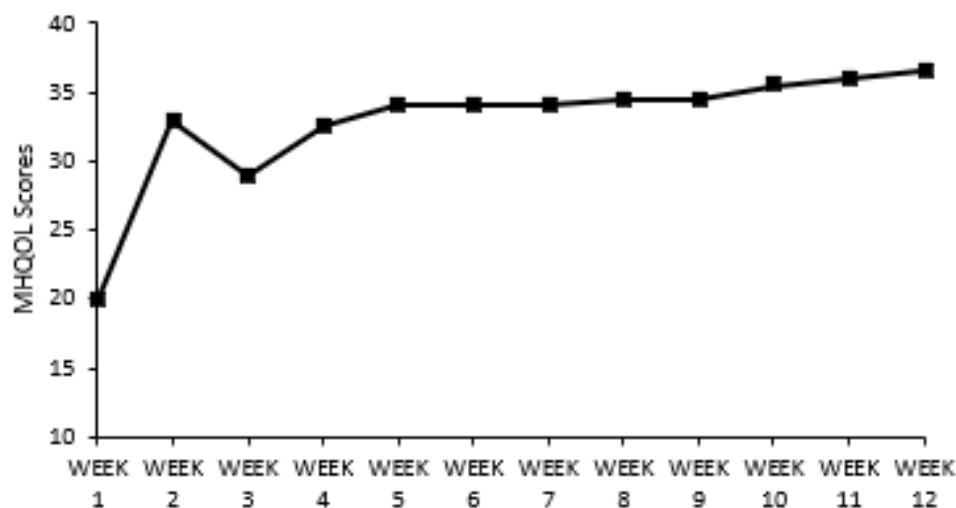
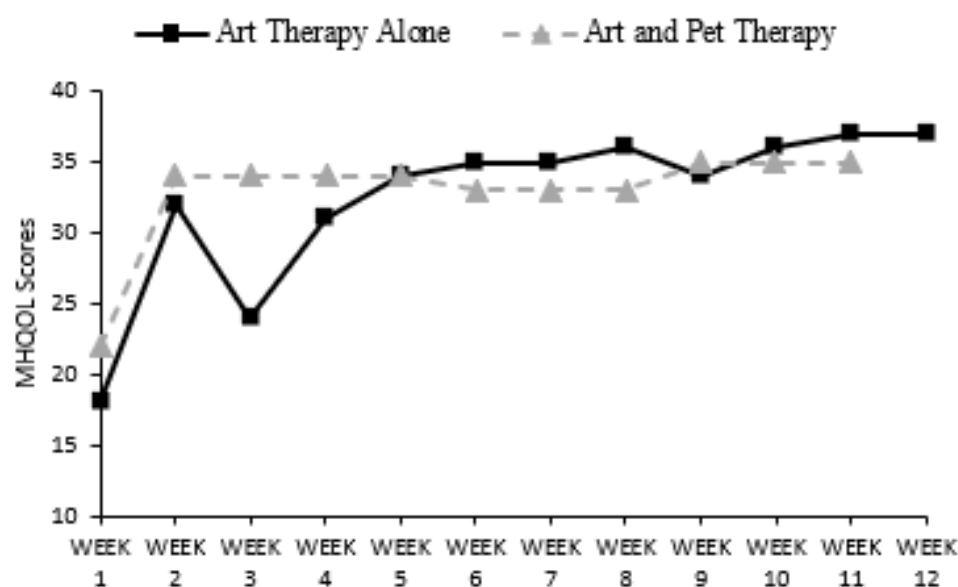
a**b**

Figure 3: MHQOL data for SITAR. MHQOL data was collected weekly for the 12-week study period. Only patients with data for the full study period were included in the analysis. (a) Total MHQOL for all patients. (b) MHQOL separated by art therapy group (n = 1) and art and pet therapy (n = 1).

Art Therapy Reduces HAM-D Scores in VS patients

The same two patients completed pre- and post-intervention, in which HAM-D surveys were administered by a clinical psychiatrist. For patient 1, the pre-intervention HAM-D was 6 which decreased to a 0 post-intervention (Fig. 4). For patient 2, the pre-intervention HAM-D was 5 which decreased to 2 post-interventions. This represents an average decrease of 80% in HAM-D scores in pre-intervention compared to post-intervention.

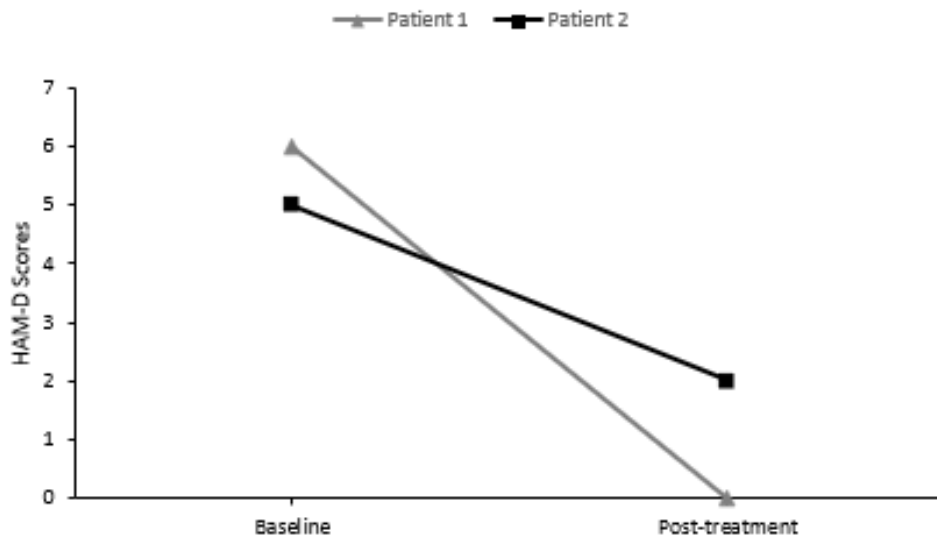


Figure 4: HAM-D scores for two patients in art therapy group. HAM-D scores were collected before the intervention and after the intervention at 12 weeks. Patient 1 was in the art therapy only group and patient 2 was in the art and pet therapy group. Both patients displayed a reduction in depressive symptoms.

Discussion

These feasibility studies provide preliminary evidence for digital-based techniques to improve QoL in both cancer and benign tumor patients. Our analysis suggests the following: (i) active music therapy has a greater positive effect on treatment-related cognitive impairment in breast cancer patients compared to receptive music therapy and (ii) both art therapy alone and art therapy combined with companion therapy improve overall QoL and reduce depressive symptoms in VS patients. This study is unique in that we offer several methods, sometimes in combination, to address general QoL issues and more specific treatment-related cognitive impairments. Additionally, the patient population is narrowed to CNS tumor populations (breast cancer being a common secondary CNS tumor) rather than general cancer populations. It is also unique for the methods to be digital apps and thus able to be used asynchronously and remotely by patients. This ensures that the interventions are low cost and widely availability to any patient with an internet connection.

Notably, the ARMCAN study showed a 44.2% increase in FACT-Cog scores after 6 months of interactive music therapy in breast cancer patients. The receptive music therapy group did not have as dramatic an increase in FACT-Cog scores. However, Group A had a lower pre-treatment FACT-Cog average compared to Group B and increases in FACT-Cog scores may be attributed to a regression to the mean. Furthermore, art therapy alone, studied in SITAR, led to a 106% increase in MHQOL scores for a VS patient by the end of the study period. Art and companion therapy combined led to a more modest 63.6% increase in MHQOL scores by the end of the study period. For both groups, increases in MHQOL scores were seen as early as Week 2 and were maintained until the end of the study. More in-depth analysis of the results is partially limited by the number of patients who completed the study. Regardless of preliminary evidence for efficacy, this study provides value in displaying evidence for feasibility for a variety of digital applications to improve QoL for breast cancer and VS.

One limitation of this study is the low n of both arms of the study. The original intention of the study was to have a proof of concept for larger, future clinical trials, so the n was intentionally low. However, this small n and subsequent large percentage of patients lost to follow-up - 80% dropout rate for SITAR, 40% dropout rate for ARMCAN - led to small patient numbers for analysis. The high dropout rate for SITAR may be attributed to the high number of checkpoints for the study and future studies may utilize longer data intervals to attain higher retention. Another limitation is that the usage rate of companion therapy was not standardized. Patients were given guidelines on usage, but they could have been over- or underusing the therapy based on personal preference. On the other hand, the art and music therapies were highly guided, so it was easier to standardize usage of these interventions.

Future directions for study include larger study size to attach significance to the results. Also, with a larger number of patients, we would be able to include a control group to compare these digital therapies to sham intervention. Interestingly, some clinical trials have used art therapy pre-chemotherapy or radiation therapy as a prophylactic measure with moderate success [37]. Another ongoing clinical trial in Spain is using art therapy to reduce anxiety and depression in a cohort of all cancer patients [38]. Similarly, Harper, et al., used music therapy during chemotherapy to effectively improve mood and reduce distress [39]. The tools presented in this study offer low-cost and accessible techniques for cancer patients to utilize technology to improve their QoL during treatment and beyond.

Conflict of Interests

Authors declare that there is no conflict of interest for this paper.

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Competing Interests

The authors have no competing interests to report.

Author Contributions

Claudia Rebola and Soma Sengupta contributed study conception and design. Meera Rastogi helped with the design of the art therapy application. Ryan Norton and Diego Gómez Enriquez assisted in designing the application. Abigail Koehler helped with the preparation of the IRB. Material preparation and data collection were performed by Claudia Rebola, Meera Rastogi, Abigail Koehler, Diego Gómez Enriquez, Avneet Ghumann, Sankhya JejuriKar, Pierce Johnston, Michelle Kirschner and Yehudit Rothman. Analysis was performed by Claudia Rebola, Rohan Rao and Soma Sengupta. The first draft of the manuscript was written by Claudia Rebola, Rohan Rao and Soma Sengupta. Review, editing and final manuscript approval was performed by all authors.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval

The ARMCAN and ARTCAN/ARCCAN pilot feasibility studies were approved by the University of Cincinnati Institutional Review Board IRB #2021-0045 and #2021-0535.

Consent to Participate

Informed consent was obtained from all individual participants included in the study.

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References

1. Donovan K, Sanson-Fisher RW, Redman S. Measuring quality of life in cancer patients. *J Clin Oncol.* 1989;7:959-68.
2. Ramasubbu SK, Pasricha RK, Nath UK, Rawat VS, Das B. Quality of life and factors affecting it in adult cancer patients undergoing cancer chemotherapy in a tertiary care hospital. *Cancer Rep (Hoboken).* 2021;4:e1312.
3. Gayatri D, Efremov L, Kantelhardt EJ, Mikolajczyk R. Quality of life of cancer patients at palliative care units in developing countries: systematic review of the published literature. *Qual Life Res.* 2021;30:315-43.

4. Walker J, Mulick A, Magill N, Symeonides S, Gourley C, Burke K, et al. Major depression and survival in people with cancer. *Psychosom Med*. 2021;83:410-6.
5. Berchuck JE, Meyer CS, Zhang N, Berchuck CM, Trivedi NN, Cohen B. Association of mental health treatment with outcomes for US veterans diagnosed with non-small cell lung cancer. *JAMA Oncol*. 2020;6:1055-62.
6. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021;71:209-49.
7. Carreira H, Williams R, Dempsey H, Stanway S, Smeeth L, Bhaskaran K. Quality of life and mental health in breast cancer survivors compared with non-cancer controls: a study of patient-reported outcomes in the United Kingdom. *J Cancer Surviv*. 2021;15:564-75.
8. Heidary Z, Ghaemi M, Hossein Rashidi B, Kohandel Gargari O, Montazeri A. Quality of life in breast cancer patients: a systematic review of the qualitative studies. *Cancer Control*. 2023;30:10732748231168318.
9. Gupta VK, Thakker A, Gupta KK. Vestibular schwannoma: what we know and where we are heading. *Head Neck Pathol*. 2020;14:1058-66.
10. Goldbrunner R, Weller M, Regis J, Lund-Johansen M, Stavrinou P, Reuss D, et al. EANO guideline on the diagnosis and treatment of vestibular schwannoma. *Neuro Oncol*. 2020;22:31-45.
11. Yao L, Alahmari M, Temel Y, Hovinga K. Therapy of sporadic and NF2-related vestibular schwannoma. *Cancers (Basel)*. 2020;12:835.
12. Halliday J, Rutherford SA, McCabe MG, Evans DG. An update on the diagnosis and treatment of vestibular schwannoma. *Expert Rev Neurother*. 2018;18:29-39.
13. Ostrom QT, Cioffi G, Gittleman H, Patil N, Waite K, Kruchko C. CBTRUS statistical report: primary brain and other central nervous system tumors diagnosed in the United States in 2012-2016. *Neuro Oncol*. 2019;21:v1-v100.
14. Kshetty VR, Hsieh JK, Ostrom QT, Kruchko C, Barnholtz-Sloan JS. Incidence of vestibular schwannomas in the United States. *J Neurooncol*. 2015;124:223-8.
15. Pruijn IMJ, Kievit W, Hentschel MA, Mulder JJS, Kunst HPM. What determines quality of life in patients with vestibular schwannoma? *Clin Otolaryngol*. 2021;46:412-20.
16. Neve OM, Jansen JC, Koot RW, Ridder M de, Paul G, Van Benthem P. Long-term quality of life of vestibular schwannoma patients: a longitudinal analysis. *Otolaryngology-Head and Neck Surg*. 2023;168:210-7.
17. Bernstein LJ, McCreath GA, Komeylian Z, Rich JB. Cognitive impairment in breast cancer survivors treated with chemotherapy depends on control group type and cognitive domains assessed: A multilevel meta-analysis. *Neurosci Biobehav Rev*. 2017;83:417-28.
18. Cramer CK, Cummings TL, Andrews RN, Strowd R, Rapp SR, Shaw EG. Treatment of radiation-induced cognitive decline in adult brain tumor patients. *Curr Treat Options Oncol*. 2019;20:42.
19. Henderson FM, Cross AJ, Baraniak AR. A new normal with chemobrain": Experiences of the impact of chemotherapy-related cognitive deficits in long-term breast cancer survivors. *Health Psychol Open*. 2019;6:2055102919832234.
20. Das A, Ranadive N, Kinra M, Nampoothiri M, Arora D, Mudgal J. An overview on chemotherapy-induced cognitive impairment and potential role of antidepressants. *Curr Neuropharmacol*. 2020;18:838-51.
21. Rao V, Bhushan R, Kumari P, Cheruku SP, Ravichandiran V, Kumar N. Chemobrain: A review on mechanistic insight, targets and treatments. *Adv Cancer Res*. 2022;155:29-76.
22. Huehnchen P, Van Kampen A, Boehmerle W, Endres M. Cognitive impairment after cytotoxic chemotherapy. *Neuro-Oncol Pract*. 2020;7:11-21.
23. Wieneke MH, Dienst ER. Neuropsychological assessment of cognitive functioning following chemotherapy for breast cancer. *Psycho-Oncol*. 1995;4:61-6.
24. Dijkshoorn ABC, van Stralen HE, Sloots M, Schagen SB, Visser-Meily JMA, Schepers VPM. Prevalence of cognitive impairment and change in patients with breast cancer: A systematic review of longitudinal studies. *Psycho-Oncol*. 2021;30:635-48.
25. Onzi GR, D'Agustini N, Garcia SC, Guterres SS, Pohlmann PR, Rosa DD, et al. Chemobrain in breast cancer: mechanisms, clinical manifestations and potential interventions. *Drug Saf*. 2022;45:601-21.
26. Bleibel M, El Cheikh A, Sadier NS, Abou-Abbas L. The effect of music therapy on cognitive functions in patients with Alzheimer's disease: a systematic review of randomized controlled trials. *Alzheimers Res Ther*. 2023;15:65.

27. Lyu J, Zhang J, Mu H, Li W, Champ M, Xiong Q, et al. The effects of music therapy on cognition, psychiatric symptoms and activities of daily living in patients with alzheimer's disease. *J Alzheimers Dis*. 2018;64:1347-58.
28. Le Perf G, Donguy AL, Thebault G. Nuanced effects of music interventions on rehabilitation outcomes after stroke: a systematic review. *Top Stroke Rehabil*. 2019;26:473-84.
29. Chen SC, Chou CC, Chang HJ, Lin MF. Comparison of group vs self-directed music interventions to reduce chemotherapy-related distress and cognitive appraisal: an exploratory study. *Support Care Cancer*. 2018;26:461-9.
30. Shaffer BT, Cohen MS, Bigelow DC, Ruckenstein MJ. Validation of a disease-specific quality-of-life instrument for acoustic neuroma: the Penn acoustic neuroma quality-of-life scale. *Laryngoscope*. 2010;120:1646-54.
31. Carlson ML, Tombers NM, Kerezoudis P, Celda MP, Lohse CM, Link MJ. Quality of life within the first 6 months of vestibular schwannoma diagnosis with implications for patient counseling. *Otol Neurotol*. 2018;39:e1129-36.
32. Uttley L, Scope A, Stevenson M, Rawdin A, Taylor Buck E, Sutton A. Systematic review and economic modelling of the clinical effectiveness and cost-effectiveness of art therapy among people with non-psychotic mental health disorders. *Health Technol Assess*. 2016;19:1-120.
33. Bosman JT, Bood ZM, Scherer-Rath M, Dörr H, Christophe N, Sprangers MAG, et al. The effects of art therapy on anxiety, depression and quality of life in adults with cancer: a systematic literature review. *Support Care Cancer*. 2021;29:2289-98.
34. Wood MJM, Molassiotis A, Payne S. What research evidence is there for the use of art therapy in the management of symptoms in adults with cancer? A systematic review. *Psychooncol*. 2011;20:135-45.
35. Holder TRN, Gruen ME, Roberts DL, Somers T, Bozkurt A. A Systematic Literature Review of Animal-Assisted Interventions in Oncology (Part I): Methods and Results. *Integr Cancer Ther*. 2020;19:1534735420943278.
36. Fogelson DM, Rutledge C, Zimbro KS. The impact of robotic companion pets on depression and loneliness for older adults with dementia during the COVID-19 pandemic. *J Holist Nurs*. 2022;40:397-409.
37. De Feudis RL, Graziano G, Lanciano T, Garofoli M, Lisi A, Marzano N. An art therapy group intervention for cancer patients to counter distress before chemotherapy. *Arts Health*. 2021;13:35-48.
38. Suñol EC. Effectiveness of art therapy in the level of anxiety and depression of cancer patients. *Multicentric Random Clinical Trial (ATANDEC)*. 2024.
39. Harper FWK, Heath AS, Moore TF, Kim S, Heath EI. Using music as a tool for distress reduction during cancer chemotherapy treatment. *JCO Oncol Pract*. 2023;19:1133-42.

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